ORTHOPAEDIC SURGERY

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MANAGEMENT OF COMPLEX CASES

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From the Director

Complex Joint Reconstruction Center

Thomas P. Sculco, MD

The Complex Joint Reconstruction Center (CJRC) was established at Hospital for Special Surgery in January 2017 to treat the most challenging cases in joint reconstruction. Since then, over 500 patients have been treated, with multidisciplinary input from expert revision joint-replacement surgeons and specialists from imaging, biomechanics, infectious disease, pathology, and basic science. Currently, 13 member surgeons have a dedicated clinical and research interest in this complex area of arthroplasty, and a registry has been created to closely monitor patient outcomes. Data from the registry are helping us determine mechanisms of failure and possible preventive strategies based on basic science and biomechanical research. Prospective outcome analysis will also aid us in improving algorithmic approaches to complex joint disorders.

The cases presented in this issue demonstrate 3 of the most challenging problems of acetabular bone loss, with solutions that ensure hip stability and proper implant selection. The authors—**Christopher Jones, MD, PhD**, and **Peter K. Sculco, MD**, in Case 1; **Jason L. Blevins, MD**, and **Alexander S. McLawhorn, MD, MBA**, in Case 2; and **Colin Y. L. Woon, MD**, **Peter H. Sun, MS**, and **Michael B. Cross, MD**, in Case 3—have clearly defined the need for thorough evaluation of anatomical deficiencies through the use of advanced imaging and 3-dimensional modeling, which provide the key to preparation for surgery. Biomechanical consultation is also crucial in aiding anatomic restoration through the use of augmentation, bone grafting, and customized implants.

These authors are experts in the treatment of such complex cases, including the potentially catastrophic complications that can arise during their management. Together, these 3 cases reinforce the need for a focused center such as the Complex Joint Reconstruction Center.

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Thomas P. Sculco, MD
Director, HSS Complex Joint Reconstruction Center
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Case 1

Case presented by Christopher W. Jones, MD, PhD, and Peter K. Sculco, MD

Dealing with Major Bone Deficits in Revision Total Hip Arthroplasty

Case Report A 59-year-old woman presented with a 3-year history of progressively worsening right buttock and groin pain radiating to her knee and requiring opioid analgesia. Born with bilateral developmental dysplasia of the hip (DDH) and congenital talipes equinovarus, the patient underwent primary right total hip arthroplasty (THA) at age 34 in 1983 and left THA in 1984. She required multiple revisions of both hips. Her most recent right THA revision in 2005 was complicated by infection requiring a 2-stage reconstruction with antibiotic spacer prior to reimplantation.

Significant medical history included hypertension, anxiety and depression, peripheral neuropathy, osteoporosis, and 30 pack-years of smoking. The patient required crutches from childhood due to DDH and a right foot drop for which she had not worn an ankle-foot orthosis. She was wheelchair dependent due to worsening pain.

Physical examination revealed multiple well-healed right hip incisions, groin and buttock pain with hip motion, and a positive log-roll test. Range of motion was from full extension to flexion, 100°; internal rotation, 30°; external rotation, 70°; abduction, 45°; and adduction, 20°. Right hip abduction power was significantly diminished (2/5). Neurovascular examination demonstrated a right foot drop with 2/5 power in the common peroneal nerve distribution. Trendelenburg and Stinchfield tests were positive. The right leg was 1 cm shorter than the left.

Baseline white blood cell count was normal, but inflammatory markers were moderately elevated (erythrocyte sedimentation rate, 47 mm/hr; C-reactive protein, 6.7 mg/L). Bilateral hip joint fluoroscopy-guided aspirations did not indicate recurrent infection. Radiographs demonstrated a hybrid right THA, with femoral stem cement mantle fracture, metal debris, and periacetabular radiolucency in all Charnley zones (Fig. 1A). Computed tomographic (CT) reconstruction revealed complex bony defects and a Paprosky IIIA acetabular defect and a Paprosky IIIA-IIIB femoral defect [1] (Fig. 1B). Further preoperative evaluation included 3-dimensional computer models of the pelvis to visualize bone defects and virtual removal of the existing prosthesis (Fig. 2).

The patient underwent single-stage revision right THA. Intraoperatively, the fascia lata, iliotibial band, and hip abductor musculature were found to be grossly deficient due to previous surgery and adverse reaction to metallosis. After encountering severe anterior cortical bone loss in addition to gluteal deficiency, the surgeon decided to change from a posterior to an anterolateral approach in order to utilize the anterior bony defect as a modified Wagner osteotomy [2]. An extended trochanteric osteotomy was required for prosthesis removal and cement extraction. Reconstruction was performed with an uncemented highly porous trabecular metal (TM) cup, superolateral TM acetabular augment, long modular tapered uncemented stem, and dual mobility articulation (Fig. 3). Results of intraoperative tissue histopathology were consistent with metallosis and polyethylene debris–induced osteolysis. Both histology and extended cultures confirmed the absence of infection.

The patient's wound healed well, with no sign of infection. At 3-month follow-up, she had progressed to full weight bearing with crutches, taking tramadol as needed. She had a range of motion from full extension to flexion of 100°, internal rotation of 20°, external rotation of 40°, abduction of 30°, and adduction of 10°. Follow-up radiographs demonstrated a well-fixed implant in excellent alignment, with no change in position from her immediate postoperative imaging.

Discussion Severe acetabular and femoral bone loss presents a significant challenge to the surgeon performing revision THA. Complications associated with these extensive surgeries are significantly increased in comparison to primary THA, with higher rates of dislocation (4% to 8%, respectively) and prosthetic joint infection (8% to 10%, respectively) [3]. Numerous strategies exist to address bone deficiencies. Acetabular reconstruction options include the use of cages, cup/cage combinations, custom flange acetabular components, and acetabular augmentation with a TM prosthesis (Fig. 4).

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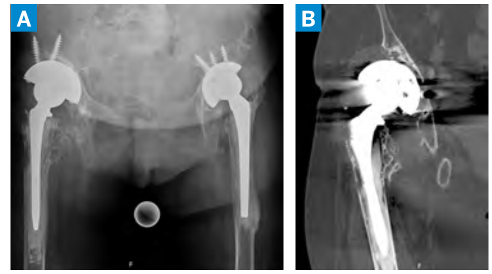

Fig. 1: (A) Preoperative radiograph demonstrating a hybrid right THA, with femoral stem cement mantle fracture, metallic debris, and periacetabular radiolucency in all Charnley zones.
(B) CT reconstruction revealing complex bony defects and a Paprosky IIIA acetabular defect and a Paprosky IIIA/IIIB femoral defect.

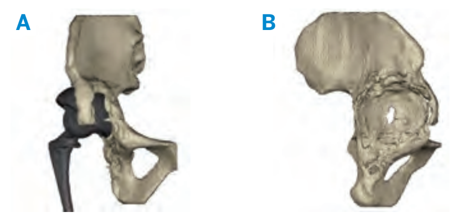

Fig. 2: Computer model of the pelvis showing (A) bone defects and (B) virtual removal of the existing prosthesis.

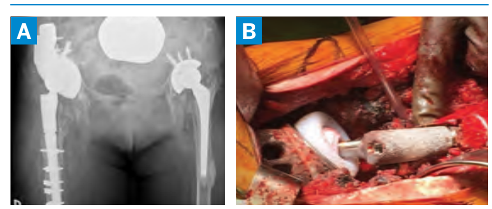

Fig. 3: (A) Postoperative radiograph showing right hip reconstruction with an uncemented highly porous TM cup, superolateral TM acetabular augment, and long modular tapered uncemented stem.
(B) Intraoperative photo showing dual mobility articulation.

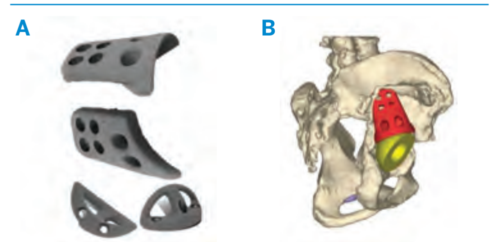

Fig. 4: (A) Custom flange acetabular components.
(B) Acetabular augmentation with TM prosthesis.

View enlarged case images

Case 2 Case presented by Jason L. Blevins, MD, and Alexander S. McLawhorn, MD, MBA

Treatment of Acetabular Bone Loss with Dual-Mobility Cup-in-Cup Construct

Case Report A 57-year-old man presented with worsening mechanical right hip pain and limb length discrepancy after multiple hip surgeries. He was injured in a motorcycle accident at age 32 and underwent open reduction and internal fixation of a right acetabular fracture. He subsequently developed post-traumatic arthritis and underwent conversion to a total hip arthroplasty (THA). He underwent 4 revision THA procedures, most recently 9 years prior. He required crutches for ambulation. He denied infectious symptoms. He was an active smoker but was otherwise healthy.

On examination, the patient had a well-healed incision over the right hip and a painful limp. Clinical limb-length measurement revealed 3-cm shortening of the right leg, with normal lower-extremity sensation, normal distal power, and 4/5 right hip abductor strength. Right hip radiographs revealed a long-stem uncemented femoral component and a loose acetabular component with broken screws and extensive osteolysis (Fig. 1). Laboratory testing was significant for elevated inflammatory markers including serum white blood cell (WBC) count of 13.9/nL, erythrocyte sedimentation rate of 9 mm/hr, and C-reactive protein level of 4.3 mg/dL. Aspiration of the right hip yielded 100 cc of clear fluid with a synovial WBC count of 0/nL and negative cultures. Additional imaging included a computed tomography (CT) scan to assess bone stock and for preoperative planning (Fig. 2).

A revision THA was performed through a posterior approach. Chronic nonunion of the greater trochanter was encountered and preserved within a digastric muscle sleeve, consisting of the gluteus medius proximally and the vastus lateralis distally. Loose hardware was removed along with metal debris deposited in the surrounding soft tissues. Intraoperative aspiration, frozen section, and cultures were negative for infection. The femoral component was stable and left in place. The acetabular component was grossly loose and easily removed. Acetabular and iliac bone loss was consistent with a Paprosky IIIa acetabulum [1]. The posterior–superior defect and acetabulum were prepared. The trabecular metal buttress was implanted as a posterior column buttress corresponding with preoperative planning. A 74-mm trabecular metal revision shell was impacted into appropriate position using computer-assisted navigation and secured with screws. Bone cement was applied to unitize the trabecular metal components, and a 60-mm dual mobility shell was cemented within the jumbo cup. A +10-mm femoral head was mated with the appropriate mobile polyethylene and reduced with good stability throughout a range of motion.

Discharged home on postoperative day 2, the patient recovered without complication and was restricted to 20-lb foot-flat weight bearing with crutches for 6 weeks. He progressed to 50% (partial) weight bearing at 6 weeks and full weight bearing at 3 months after surgery. He reported no hip pain, minimal limp, and resolution of his limb length discrepancy.

Discussion Revision acetabular surgery presents a challenge to achieving stable fixation and reducing the chance of instability. Paprosky IIIa acetabular defects can be treated with a trabecular metal augment and trabecular metal shell. Jenkins et al. recently reported a retrospective review of 85 hips treated with this type of construct with 97% survivorship at 10 years [2]. Cementing a liner within a well-fixed cup has been described by Beaulé et al. with a 78% 5-year survival rate and a 22% dislocation rate [3]. Increased instability after revision hip surgery is a commonly encountered complication [4]. Thus, articulations with enhanced stability, such as dual-mobility constructs and fully constrained liners, should be strongly considered for use in revision THA. A fully constrained liner was not used in this case, as it may have a higher risk of failure in patients of younger age and with higher activity levels [5]. The use of a dual-mobility cup has been shown to reduce dislocation rates after revision THA [6]. In the current case, the cup-in-cup construct using (1) the trabecular metal cup and augment and (2) a dual-mobility bearing couple maximized the probability of biological fixation and minimized the risk of postoperative instability, respectively.

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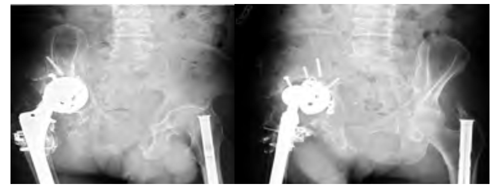

Fig. 1: Preoperative Judet radiographs of the right hip showing acetabular and iliac bone loss with broken hardware and evidence of loose acetabular component.

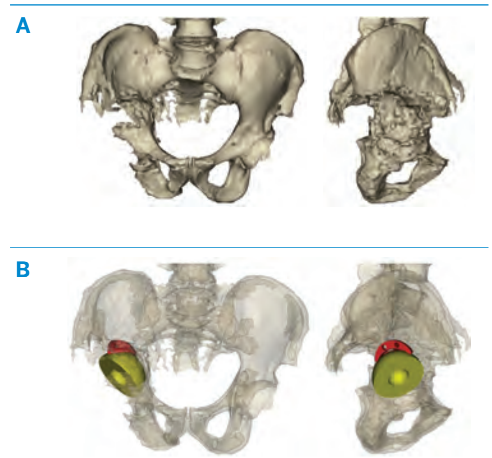

Fig. 2: A) Anteroposterior and lateral CT 3-dimensional reconstructions of pelvis used for preoperative planning revealing Paprosky IIIa acetabular defect and B) Anteroposterior and lateral reconstructions showing planned orientation of trabecular metal buttress and shell.

Fig. 3: Intraoperative photo of final acetabular reconstruction.

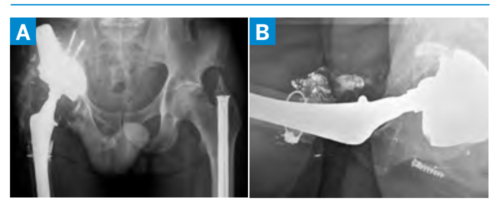

Fig. 4: Postoperative right hip radiographs: A) antero posterior view; B) cross-table lateral view.

View enlarged case images

Case 3

Case presented by Colin Y. L. Woon, MD, Peter H. Sun, MS, and Michael B. Cross, MD

Revision Custom Acetabular Biflange Implant for Large Acetabular Defects After Failed Custom Triflange

Case Report A 55-year-old woman presented with worsening left groin and lateral hip pain for 2 months that was aggravated by weight bearing and shifting of body weight, particularly in bed. She also noted "noises" coming from her hip with activity. Her medical history included juvenile rheumatoid arthritis requiring multiple orthopaedic surgeries, as well as hypothyroidism and chronic bilateral foot drop. She was not taking disease-modifying antirheumatic drugs (DMARDs), biologics, or steroids for rheumatic disease.

The patient had bilateral total hip arthroplasty (THA) at age 13 and had subsequently undergone multiple revision hip procedures. Her most recent left hip surgery, 7 years prior, was revision using a custom triflange acetabular component and a modular tapered femoral component.

At baseline, the patient was confined to a wheelchair, using her lower limbs for transfers. She wore ankle-foot orthotics on both lower extremities. On physical examination, she was 4 ft., 10 in. tall and weighed 148 lbs. (body mass index, 30.9). She had 0° to 90° of active flexion in both hips; muscle strength of 4/5 for hip flexion and extension and knee extension and flexion; and ankle and great toe dorsiflexion strength of 0/5.

Serial radiographs revealed a failed left acetabular triflange component with loosening of the ischial and ilial flanges (Fig. 1). Computed tomographic (CT) imaging showed radiolucency medial to the acetabular component along with displacement of the ischial portion of the left triflange, suggestive of loosening (Fig. 2). Tests for infection including erythrocyte sedimentation rate, C-reactive protein level, and hip aspiration were negative.

The patient underwent revision left THA with a custom biflange acetabular component. To reduce the risk of early prosthetic loosening, initial fixation was enhanced by cement injected into ischial screw holes prior to screw placement (Fig. 3). With distalizing and medializing of the acetabular component the hip could not be reduced, but stable reduction was achieved by shortening the proximal body of the modular tapered stem. Preoperative planning using 3-dimensional reconstructions and computer modeling—in collaboration with the HSS Biomechanics Department—allowed shortening of the femoral component to be anticipated. Intraoperatively, it was necessary to elevate the sciatic nerve, which was encased in scar tissue adhering to the posterior ischium.

Postoperative radiographs showed accurate placement of the acetabular component (Fig. 4). The patient was toe-touch weight bearing for 6 weeks after surgery; weight bearing was increased gradually over several months. Eight months after surgery she uses a walker, weight bearing as tolerated, for short distances and has no pain in her hip.

Discussion A biflange or triflange acetabular component is a customizable implant option for Paprosky IIIA-IIIB defects [1-4]. These custom components for large acetabular defects are rigid (unlike traditional cages) and have the potential for biologic ongrowth; a plasma-sprayed porous coating with a hydroxyapatite layer promotes bone ongrowth. The implant can address large amounts of bone loss while providing immediate fixation using multiple screws.

When a previous custom triflange acetabular implant has failed, leaving large acetabular defects, the surgeon must determine the reasons for failure so as to increase the chance of success of the next implant. In this case, contributing factors included poor existing bone stock, the small number of screws used in the ischial and ilial flanges, the older screw design (closely spaced shallow threads leading to reduced screw pullout strength), and failure to medialize the cup as much as possible to improve hip biomechanics.

The surgical team employed several engineering and surgical principles to enhance fixation while addressing the existing defect: (1) 7 screws were placed in the ilium, the largest bony contact point; (2) 5 ischial screws were placed, including a long "homerun" screw (Fig. 3), which reduces the risk of ischial lift off (the most common mode of failure from posterior–superior

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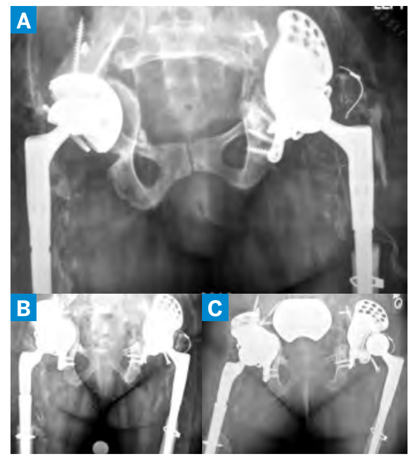

Fig. 1: Serial radiographs showing progressive loosening of left triflange implant: A) immediate postoperative; B) 4 years later; C) 7 years later.

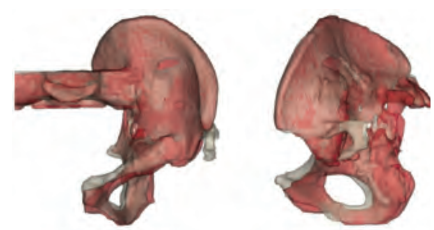

Fig. 2: Comparative 3-dimensional reformatted CT images showing a shift in ischial position from 2010 (shown in red) to 2017 (shown in gray), suggestive of loosening.

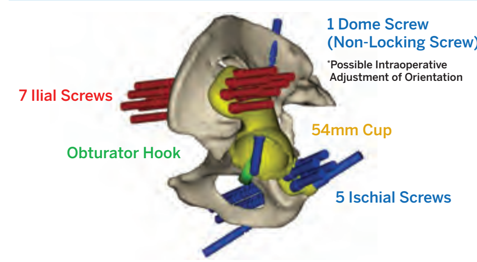

Fig. 3: Biflange construction demonstrating ilial screws, ischial screws (including long homerun screw), dome screw, and obturator hook.

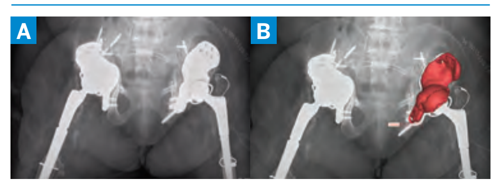

Fig. 4: Postoperative images: A) immediate postoperative image of the left hip; B) planned position compared with actual position, showing < 4 mm discrepancy.

View enlarged case images

Case 1 Continued

Trabecular metal (tantalum) is a highly porous bioinert metal ideal for complex arthroplasty applications, providing initial stability through an extremely high co-efficient of friction. Rapid bony ingrowth and final stability is facilitated by the implant's high surface area. A TM acetabular implant, augmented with a superior and lateral buttress, enables acetabular reconstruction providing strong mechanical support and secure biological ingrowth surface. TM augments used to treat acetabular defects have demonstrated consistent improvement in patient-reported outcome measures and a low rate of complications [3-5].

In this case, preoperative computer modelling and a 3-dimensional printed solid model gave the surgeon extensive information on the intricate pattern of bone loss and the ideal component position. Thus, the surgeon could decide how to work with very limited bone stock, particularly in the medial and posterior acetabular regions. This case demonstrates the principles integral to success in revision THA, including multidisciplinary preoperative planning, selection of a prosthesis that provides initial and long-term fixation when faced with extensive bone loss, and an ability to change the surgical approach to accommodate unexpected findings.

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Case 2 Continued

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Case 3 Continued

directed forces of an adducted hip); (3) a long dome screw was placed along the sciatic buttress (Fig. 3); (4) a biflange design with only 2 points of bone contact is easier to seat than a traditional triflange implant; an obturator hook that adds an extra point of fixation against ischial liftoff to a biflange construct can also be used, considered in this case but not required; (5) safe implant placement requires a large posterolateral exposure and identification of the sciatic nerve; and (6) purposely medializing the hip center reduces shear forces, reducing the risk of late implant failure [5].

Medializing the implant is necessary as the constrained liner effectively lateralizes the hip center by up to 3 mm. As seen in our case, shortening of the modular femoral component may be necessary for subsequent joint reduction in multiply revised individuals with a high hip center and large amounts of scar tissue. This case also highlights the importance of the multidisciplinary approach that is often necessary for these complex cases.

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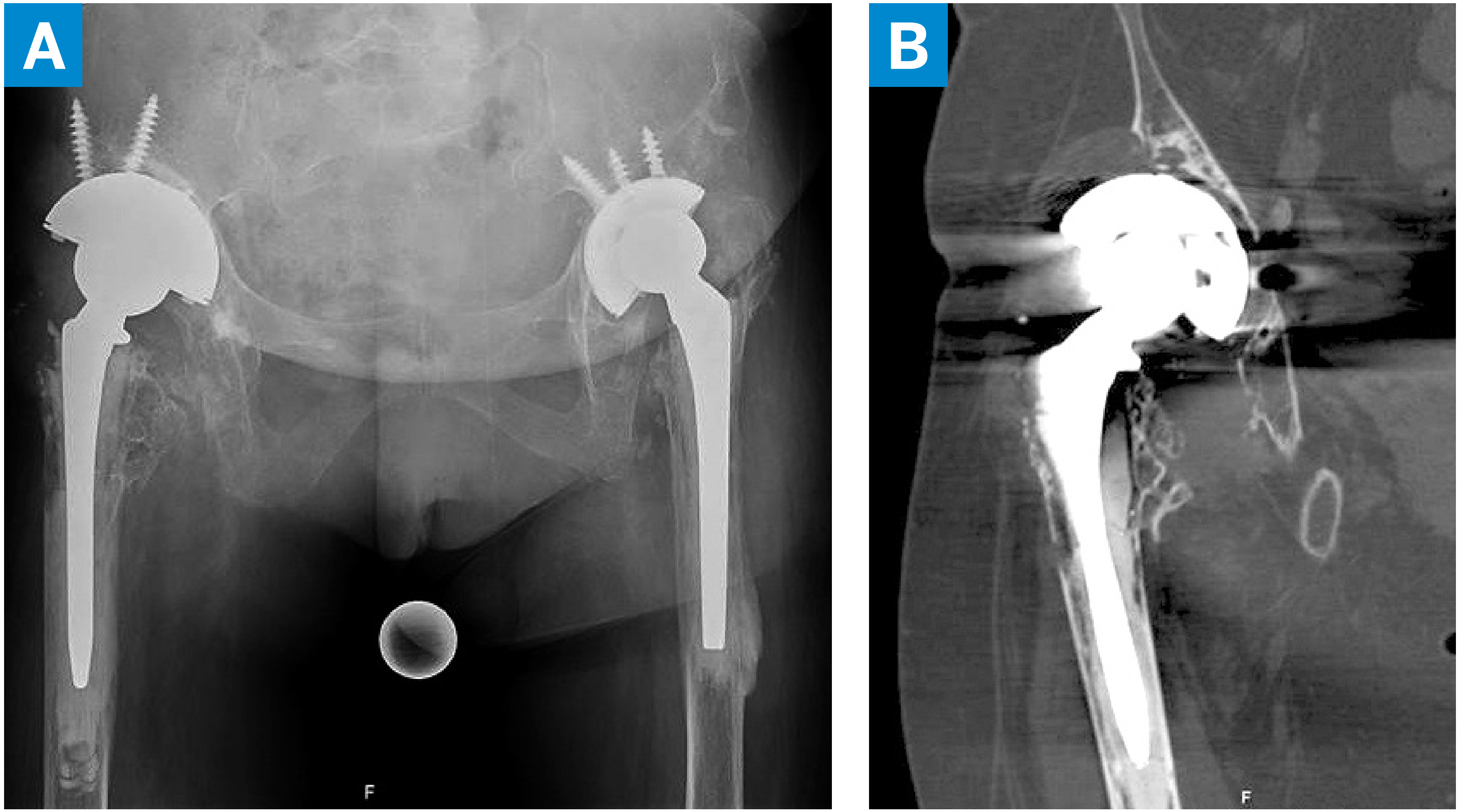

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(B) CT reconstruction revealing complex bony defects and a Paprosky IIIA acetabular defect and a Paprosky IIIA/IIIB femoral defect.

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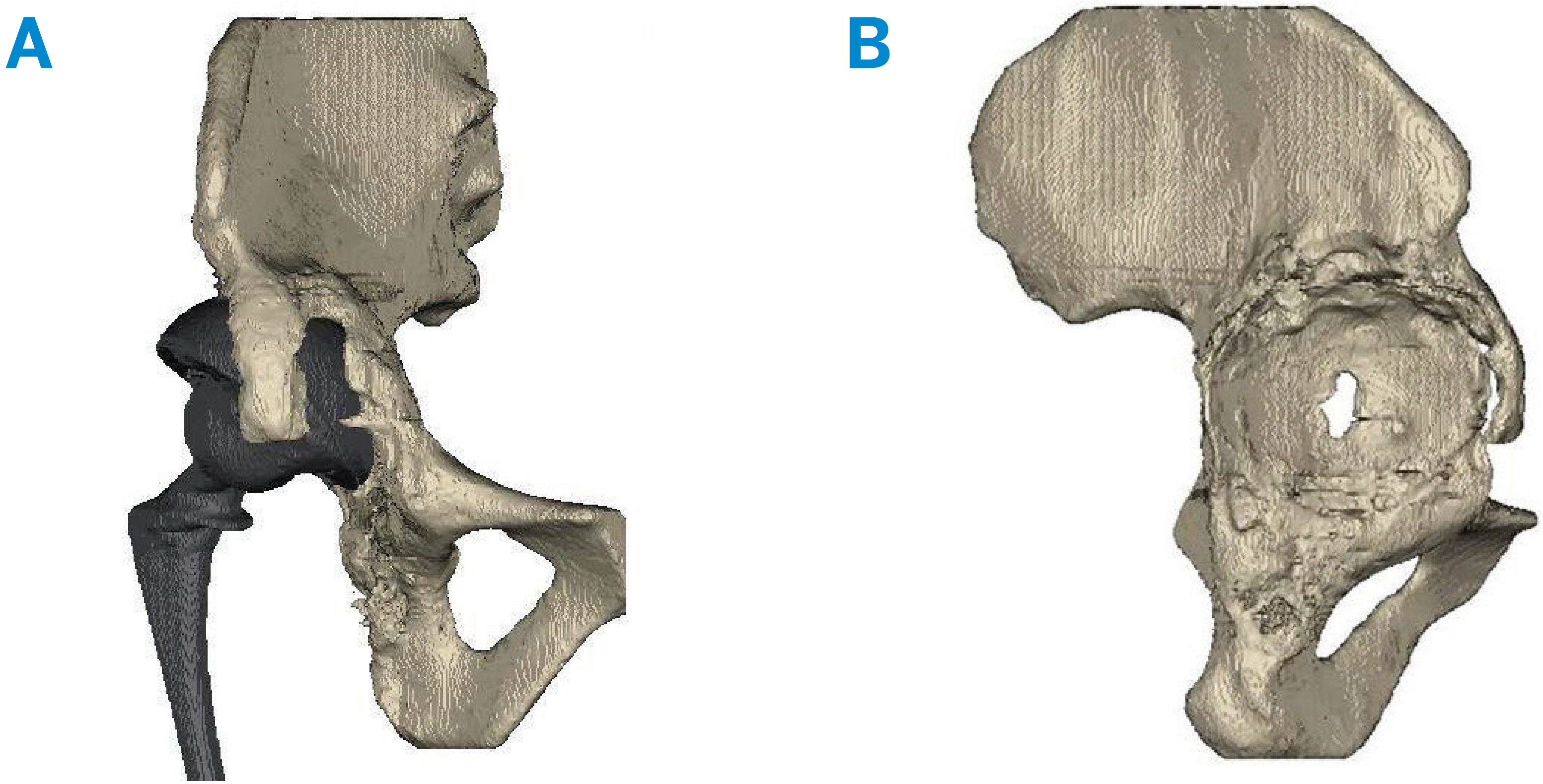

Figure 2: Computer model of the pelvis showing (A) bone defects and (B) virtual removal of the existing prosthesis.

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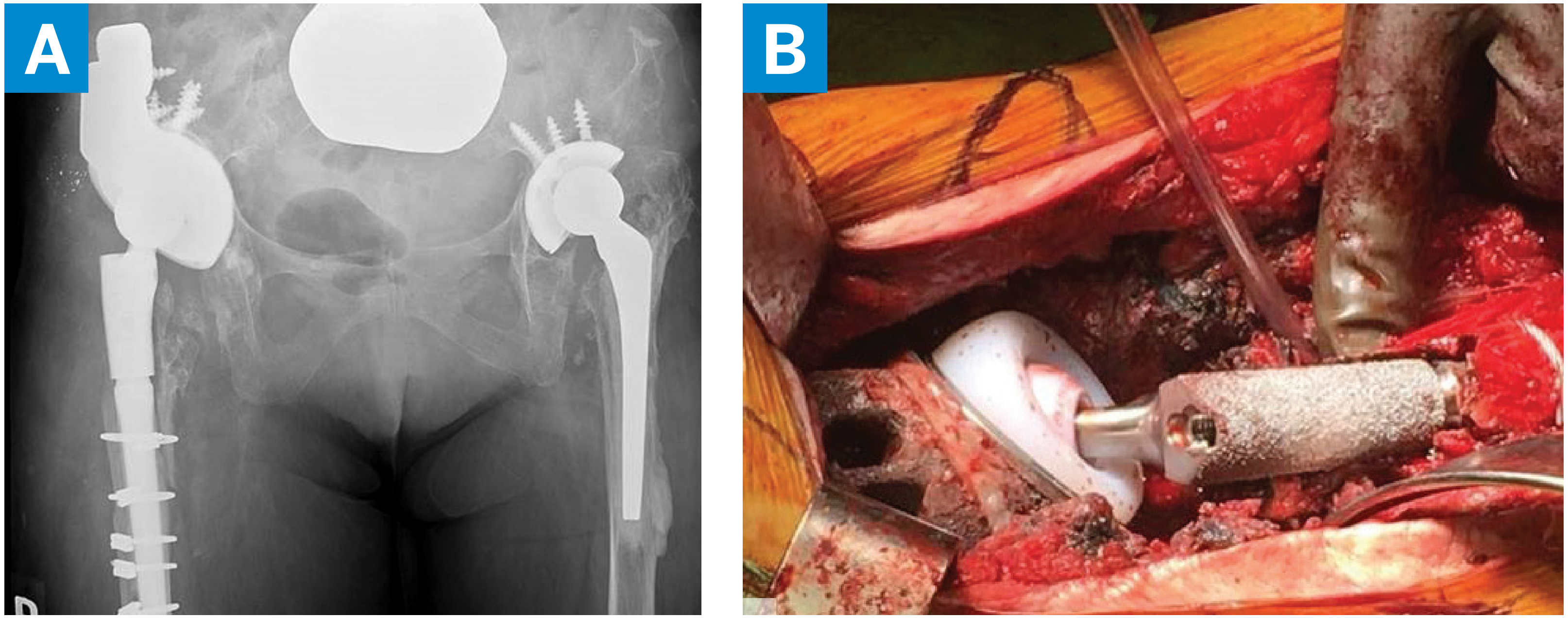

Figure 3: (A) Postoperative radiograph showing right hip reconstruction with an uncemented highly porous TM cup, superolateral TM acetabular augment, and long modular tapered uncemented stem.
(B) Intraoperative photo showing dual mobility articulation.

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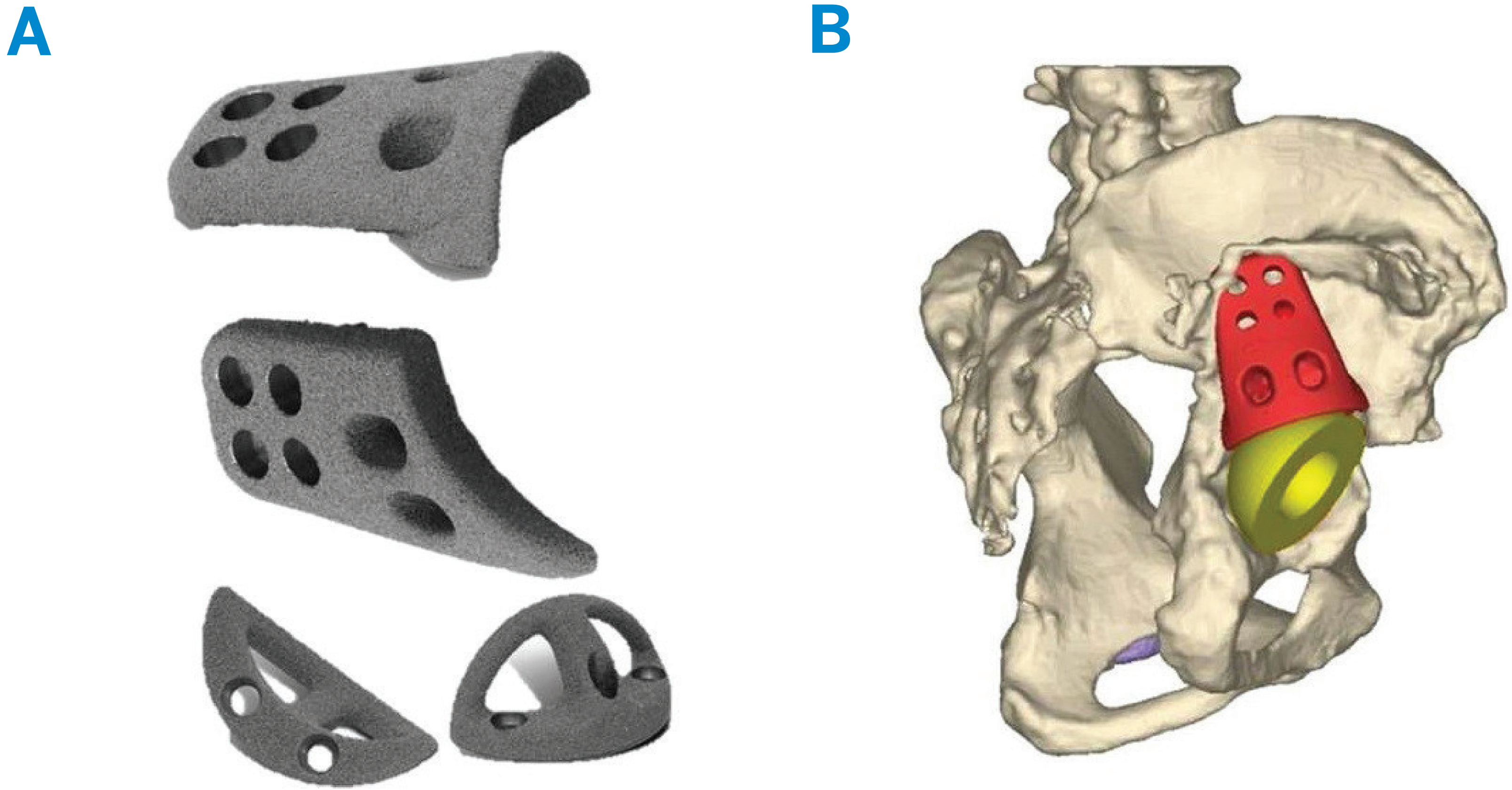

Figure 4: (A) Custom flange acetabular components. (B) Acetabular augmentation with TM prosthesis.

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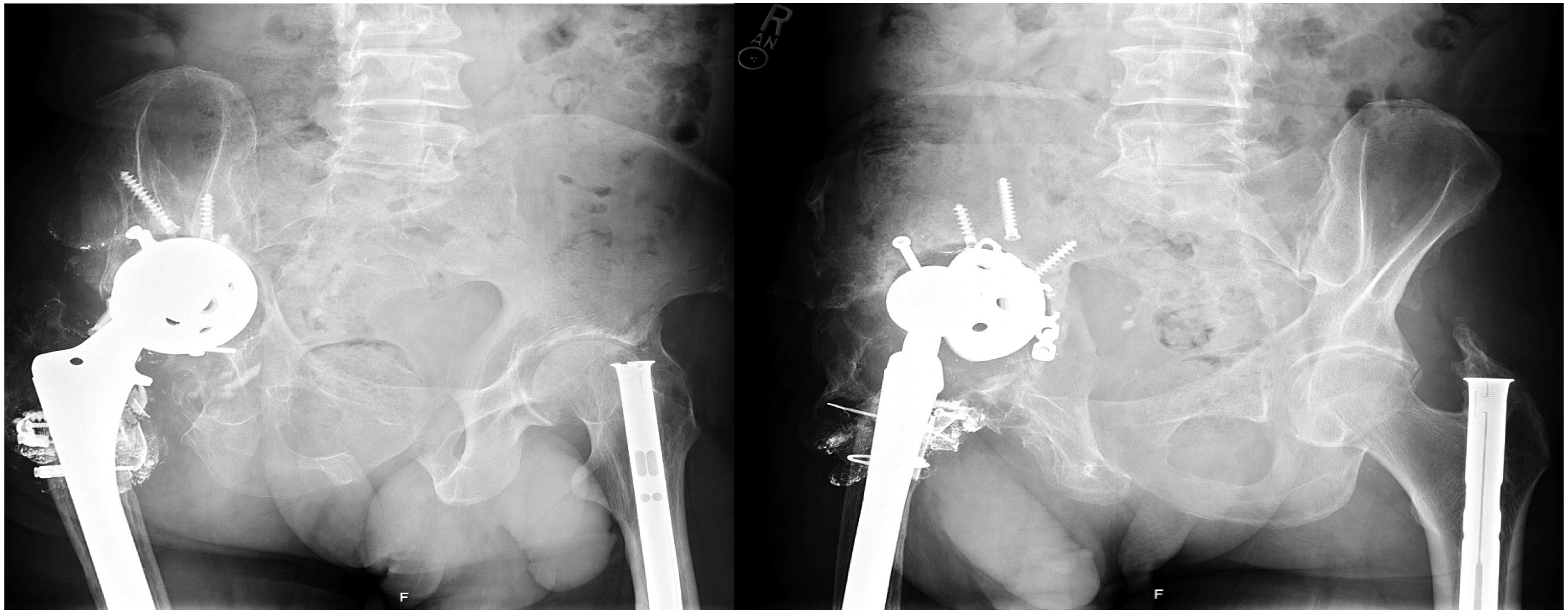

Figure 1: Preoperative Judet radiographs of the right hip showing acetabular and iliac bone loss with broken hardware and evidence of loose acetabular component.

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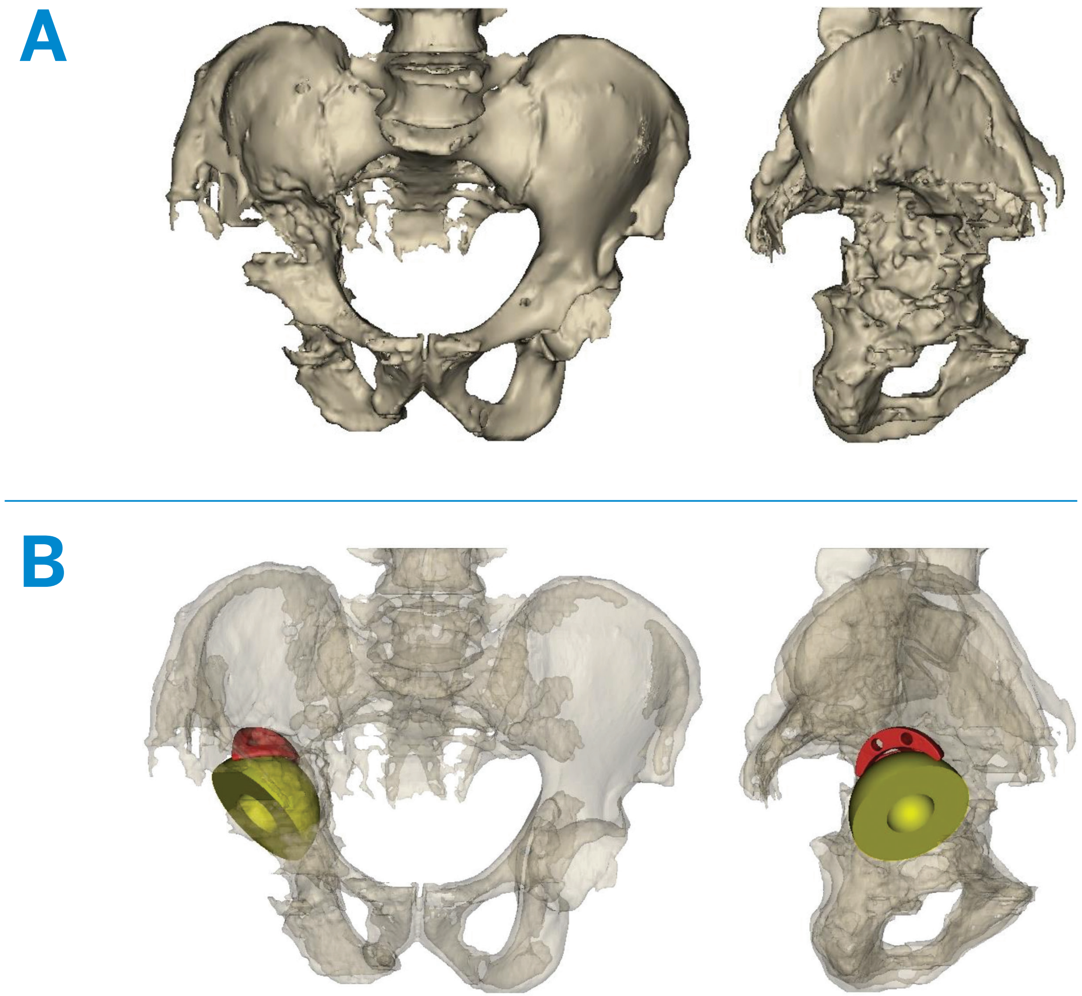

Figure 2: A) Anteroposterior and lateral CT 3-dimensional reconstructions of pelvis used for preoperative planning revealing Paprosky IIIa acetabular defect and B) Anteroposterior and lateral reconstructions showing planned orientation of trabecular metal buttress and shell.

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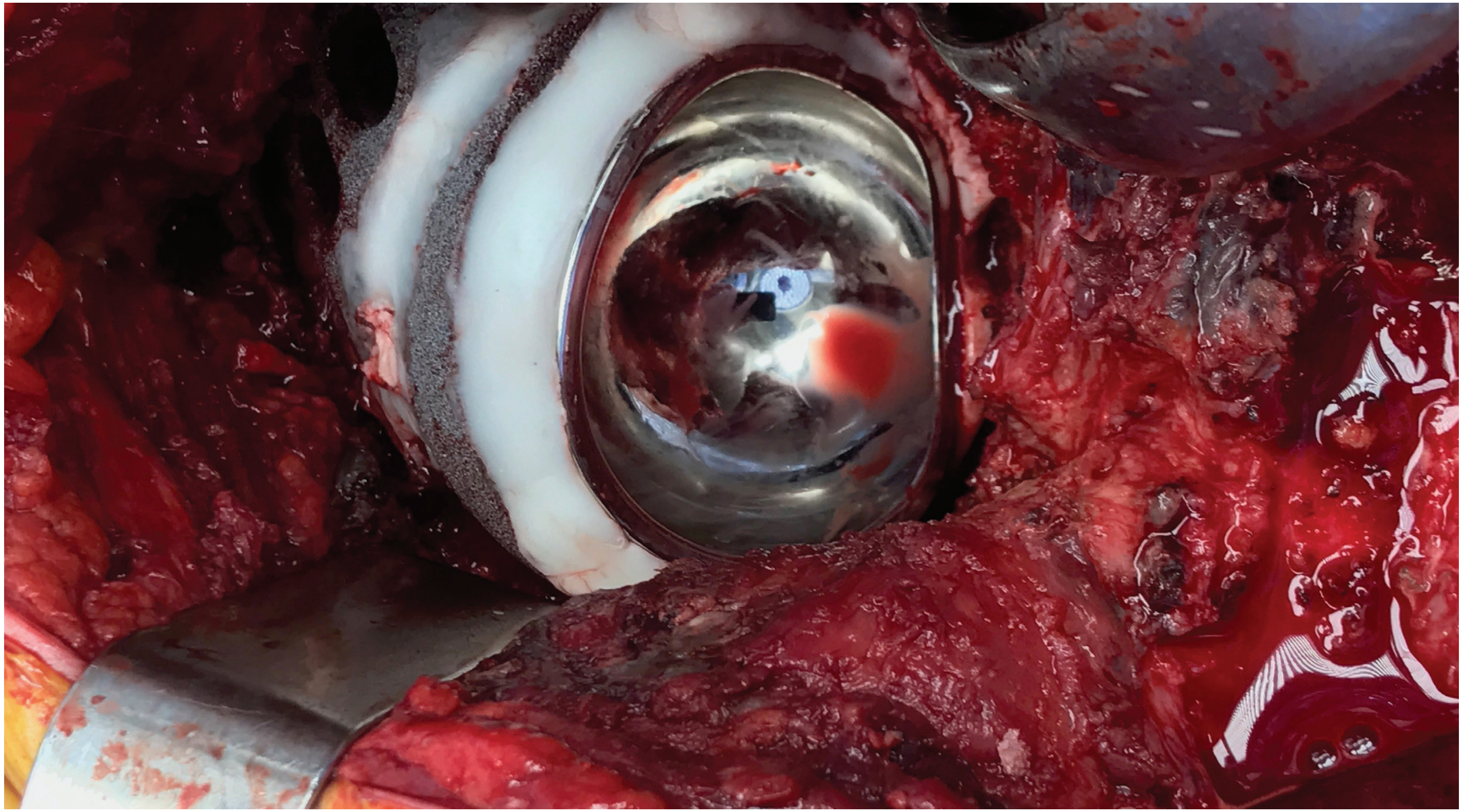

Figure 3: Intraoperative photo of final acetabular reconstruction.

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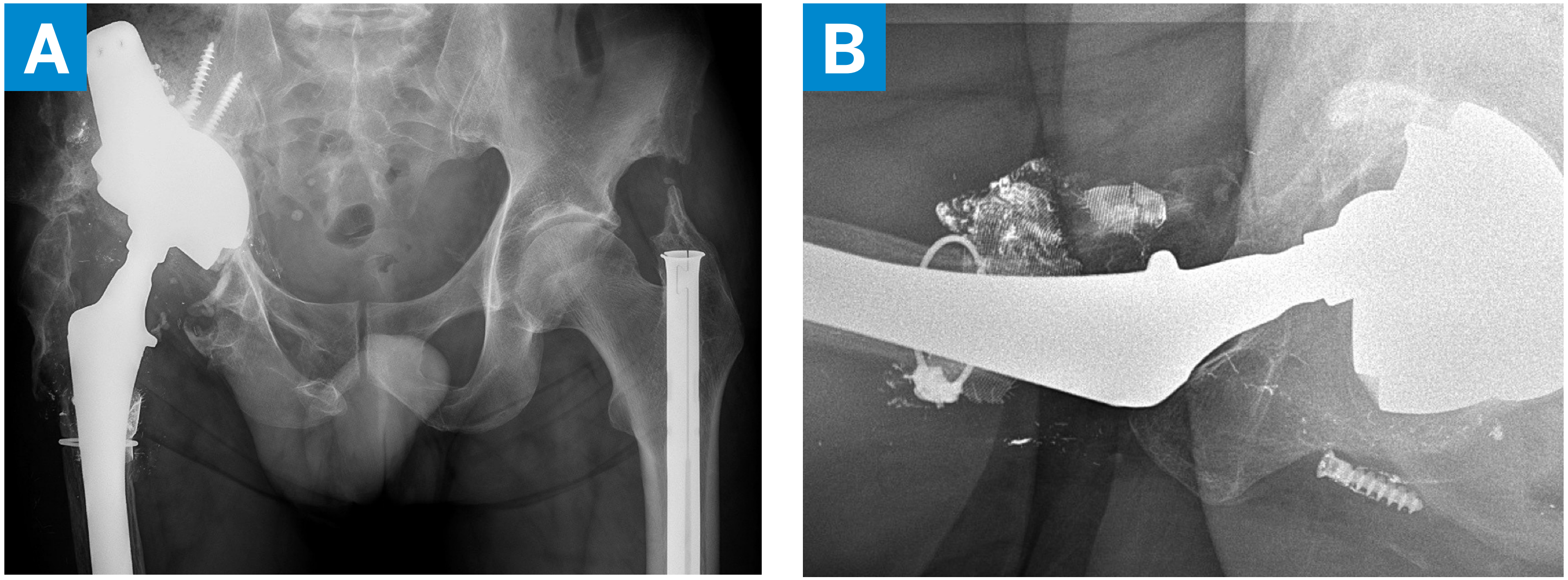

Figure 4: Postoperative right hip radiographs: A) antero posterior view; B) cross-table lateral view.

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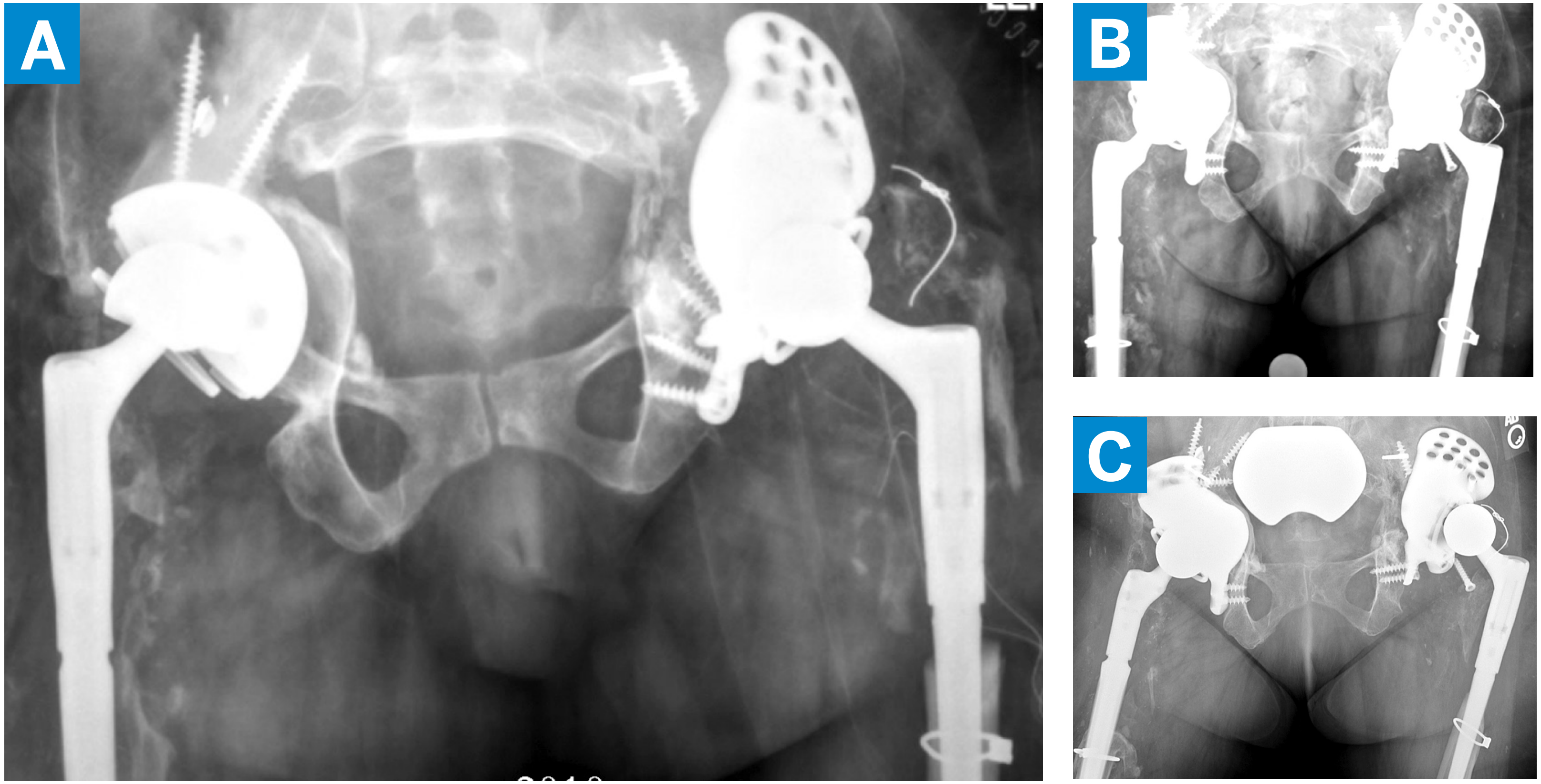

Figure 1: Serial radiographs showing progressive loosening of left triflange implant: A) immediate postoperative; B) 4 years later; C) 7 years later.

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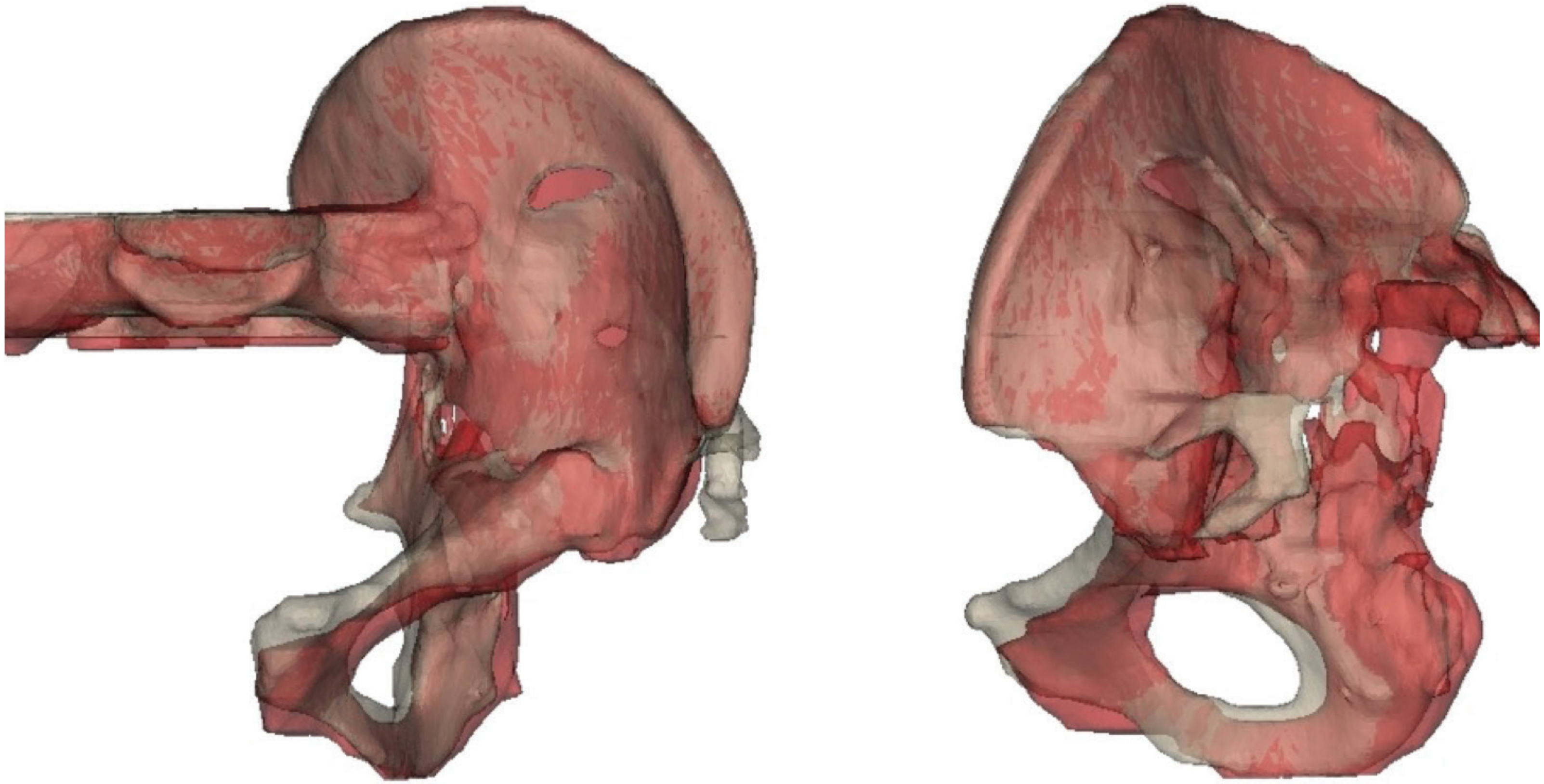

Figure 2: Comparative 3-dimensional reformatted CT images showing a shift in ischial position from 2010 (shown in red) to 2017 (shown in gray), suggestive of loosening.

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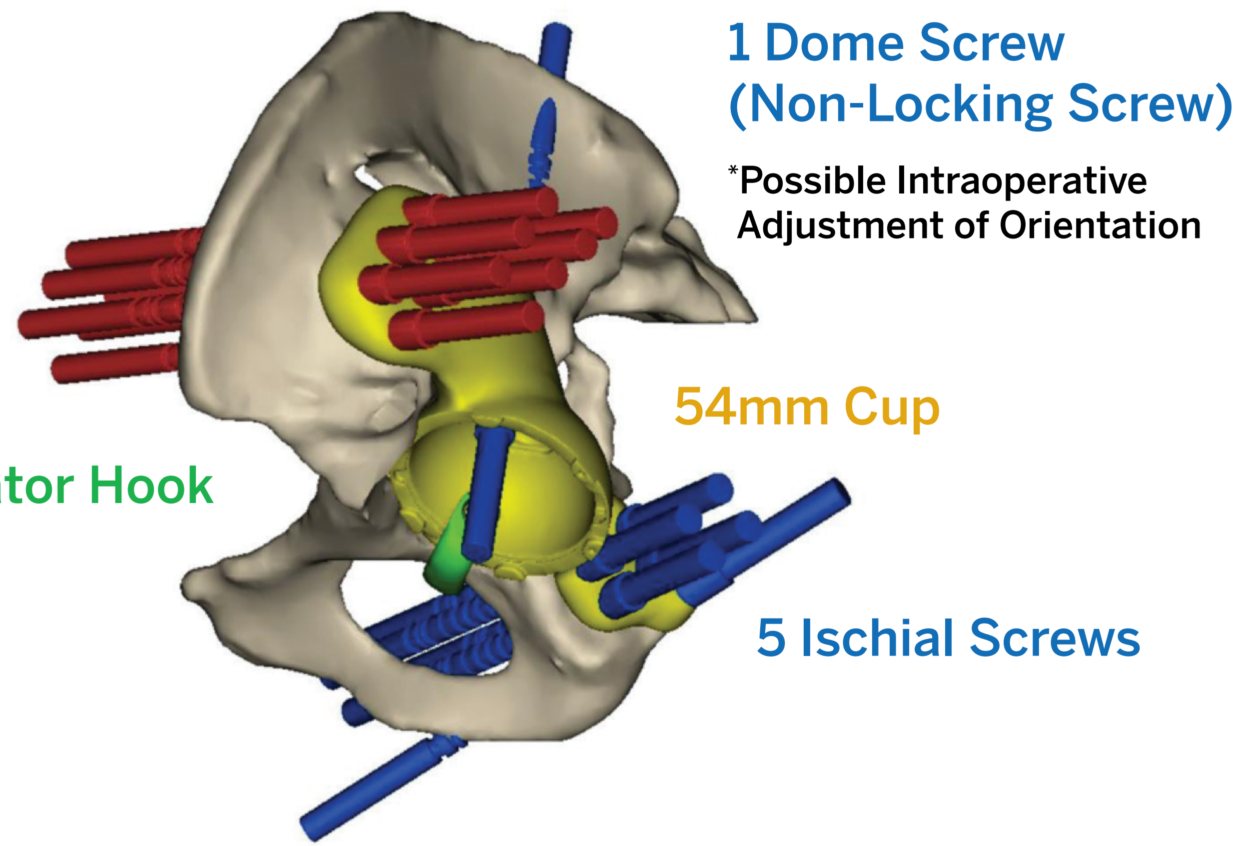

Figure 3: Biflange construction demonstrating ilial screws, ischial screws (including long homerun screw), dome screw, and obturator hook.

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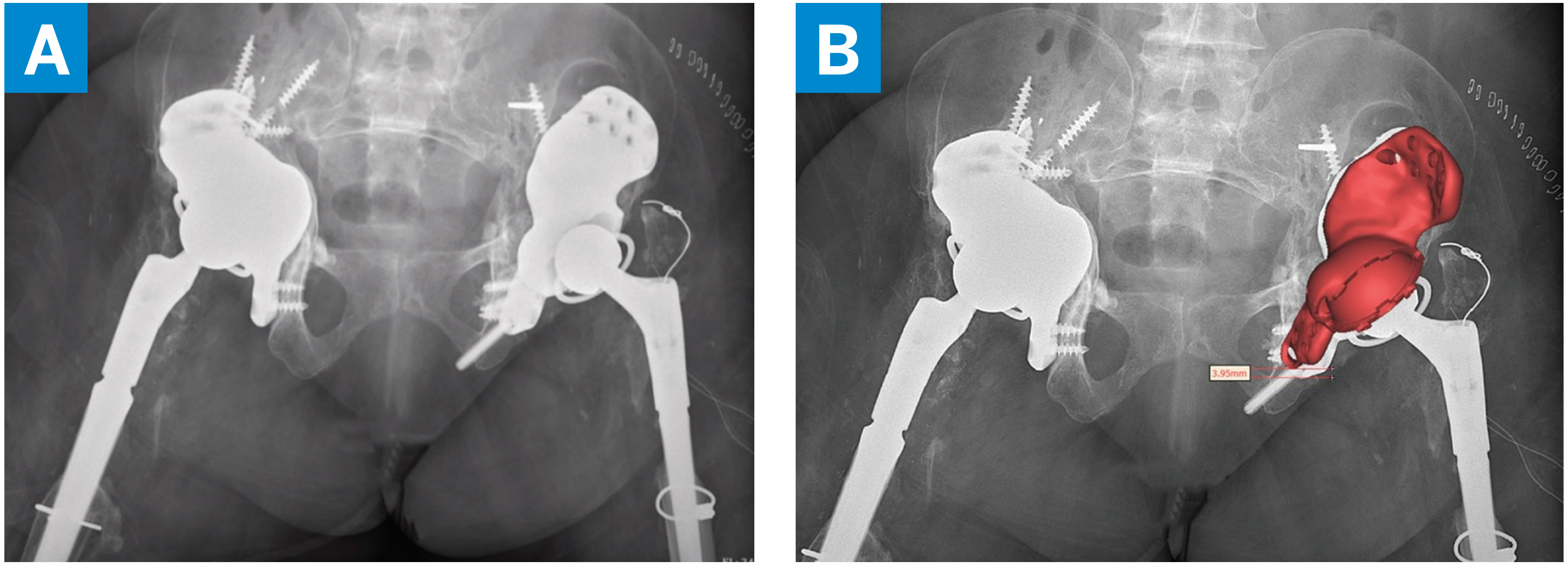

Figure 4: Postoperative images: A) immediate postoperative image of the left hip; B) planned position compared with actual position, showing < 4 mm discrepancy.

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